

# FCC-hh Physics Analysis Meetings

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Heather Gray, Filip Moortgat



# Introduction

- The Conceptual Design Report (CDR) needs to be written over the next year as input for the European Strategy Meeting
- Plan to evaluate the baseline FCC-hh detector's performance, using a set of physics benchmarks (see back up for details)
- To facilitate analysis progress, we'll hold short meetings once a month from 4-6 pm on Tuesday
  - Please send us an email if you'd like to report progress however incremental
- Foresee summary reports in the hadron detector meeting as the analyses mature
- Goal is to use the **FCC software** and the **baseline Delphes card** described [here](#)
- For certain benchmarks, these studies may be complemented by full simulation studies of selected aspects
  - To be discussed!

# Technical details

- Software setup and analysis tutorial
  - PDF: NNPDF30\_nlo\_as\_0118 (Suitable for both LO and NLO)
  - Contact Michele if you run into any problems
- Clement and Michele have produced a set of signal and background samples
  - HH, ttH, ZH: 10M
  - tt-W-Z-QCD + 0/1/2j : 10M
  - QCD + 0/1/2j : Coming soon
- The LHE and FCCSW files can be accessed here:
  - /eos/fcc/hh/generation/mg5\_amcatnlo/lhe
  - /eos/fcc/hh/generation/DelphesEvents
- The software is now working on the batch system, so there is the possibility to produce samples on demand
- Webpage detailing the available samples

# Back up: Benchmarks

# Higgs Benchmarks 1

- **Higgs Self-Coupling** (b-tagging, jet mass resolution)
  - $bb\gamma\gamma$  (photon resolution, photon  $p_T$  and  $\eta$  acceptance)
    - Michele Selvaggi, Weiming Yao?
  - $bb+\tau\tau$  ( $\tau$ -tagging)
  - $bb+ZZ, \underline{bb+WW}$  (lepton  $p_T$  and  $\eta$  acceptance, efficiency, resolution)
    - Paolo Giacomelli, Silvie Brabant, Nicola de Filippis, Biagio di Micco
  - $bbbb$ 
    - Clement Helsens, Peter Riley
- **Top-Yukawa Coupling**
  - $ttH/ttZ: H \rightarrow \gamma\gamma$
  - boosted  $ttH$  (substructure, b-tagging)  $H \rightarrow bb$ 
    - Clement Helsens
  - Study to do: compare  $H \rightarrow \gamma\gamma$  and  $H \rightarrow bb$  to understand the interplay between boost and backgrounds

(key performance aspect)

no manpower

# Higgs Benchmarks 2

- **Rare Higgs Decays**

- $H \rightarrow cc$  (charm tagging)
  - Andy Chisholm, Heather Gray ?
- $H \rightarrow \mu\mu$  (dimuon mass resolution)
  - Sinead Farrington?
- $H \rightarrow \rho\gamma$ , etc

- **VBF+VBS**

- $WW$  scattering
  - Andre Sznajder+student?, Pietro Govoni?
- VBF  $H \rightarrow \gamma\gamma$  (forward coverage and performance)
  - Istanbul? (Sehban Kartal et al)
- VBF  $H \rightarrow WW$  (forward jet coverage and performance)
  - Pietro Govoni+Lucrezia Bruni

# Higgs Benchmarks 3

## • Precision SM Higgs Couplings

- $H \rightarrow \gamma\gamma$  (photon resolution, photon  $p_T$  and  $\eta$  acceptance)
  - Marco Delmastro ?
- $H \rightarrow WW$  (lepton  $p_T$  and  $\eta$  acceptance, efficiency, resolution)
  - Biagio di Micco?
- $H \rightarrow ZZ \rightarrow 4l$ 
  - Michele Selvaggi, Paolo Giacomelli?, Silvie Brabant?
- $H \rightarrow bb$  (b-tagging, jet mass resolution)
  - Paolo Francavilla? Heather Gray (Arturo Rodriguez) ?
- $H \rightarrow \tau\tau$  ( $\tau$ -tagging)
  - Sinead Farrington?

*Need to explore the different analysis techniques that will be needed at 100 TeV compared to the LHC*

## • BSM Higgs Bosons

- High Mass neutral (500 GeV, 1 TeV, 2 TeV):  $\tau\tau$ ,  $bb$ ,  $\mu\mu$  ( $\tau$ -tagging, b-tagging)
- High Mass charged (500 GeV, 1 TeV, 2 TeV):  $\tau\nu$ ,  $tb$  (b-tagging, MET,  $\tau$ -tagging)
  - Iklay Cakir, Orhan Cakir

# SM and Top Benchmarks

- Would also like to add a few key SM and top benchmarks to the list
- Some preliminary ideas
  - $W \rightarrow \tau\nu$  BR
  - Top
    - s-channel single top production at high  $p_T$
    - FCNC coupling
      - Abdulkadir Senol, Haluk Denizli
  - Drell-Yan at high mass



# BSM Benchmarks I

- **Basic SUSY Benchmarks** (MET resolution)
  - Squarks & Gluinos
    - $M_{\text{gluino}}=12$  TeV, MLSP = 100 GeV (max mass reach)
    - $M_{\text{gluino}}=8$  TeV, MLSP = 7.8 TeV (compressed)
      - Mike Hance
  - Stops
    - $M_{\text{stop}}=9$  TeV, MLSP = 100 GeV (max mass reach)
    - $M_{\text{stop}}=5$  TeV, MLSP = 4.8 TeV (compressed)
      - Owen Colegrove , Alan Barr?
  - Electroweakinos
    - 3&4-leptons + MET
    - soft 1 or 2 lepton(s) + MET (for wino/higgsino LSP scenarios) (low  $p_T$  muon ID)
- **Exotic long-lived particles**
  - Disappearing tracks; Displaced vertices

*Need full simulation*

# BSM Benchmarks 2

- **Dark Matter**

- monojet + MET
  - Phil Harris
- VBF jets + MET
  - Summer student?
- Disappearing tracks

- **Heavy Resonances + Non-resonant?**

- $Z' \rightarrow tt$ : 5, 30 TeV (**b-tagging, substructure**)
  - Koji Terashi, Suat Ozkorucuklu? Sergei Chekanov?
- $Z' \rightarrow \mu\mu, ee$ : 5, 30 TeV (**high  $p_T$   $e/\mu$  resolution**)
  - Nate Avish
- $Z' \rightarrow jj, bb$ : 5, 30 TeV (**high  $p_T$  di-jet mass resolution, b-tagging**)
  - Caterina Doglioni + summer student, Andrea Coccaro
- $Z' \rightarrow \tau\tau$ : 5, 30 TeV ( **$\tau$ -tagging**)
  - Sinead Farrington?

*Studies intended to characterise detector performance rather than these specific physics models*

# Conclusion and Timeline

- Identified a set of **key benchmarks** for the FCC-hh machine
- Work has already started on many of them but we now need a focussed effort to get them in place for the CDR
  - Three/four CERN **summer student proposals** are being submitted
  - Excellent short term projects for students
  - Need at least **5 additional people** to cover critical channels
- Plan to review progress at **monthly meetings**
  - FCC week as goal to have first studies in all critical channels
- Please **get in contact** with us if you're working on something not yet on the list or would like to help with any of the uncovered items
  - There's room for more people on essentially every topic